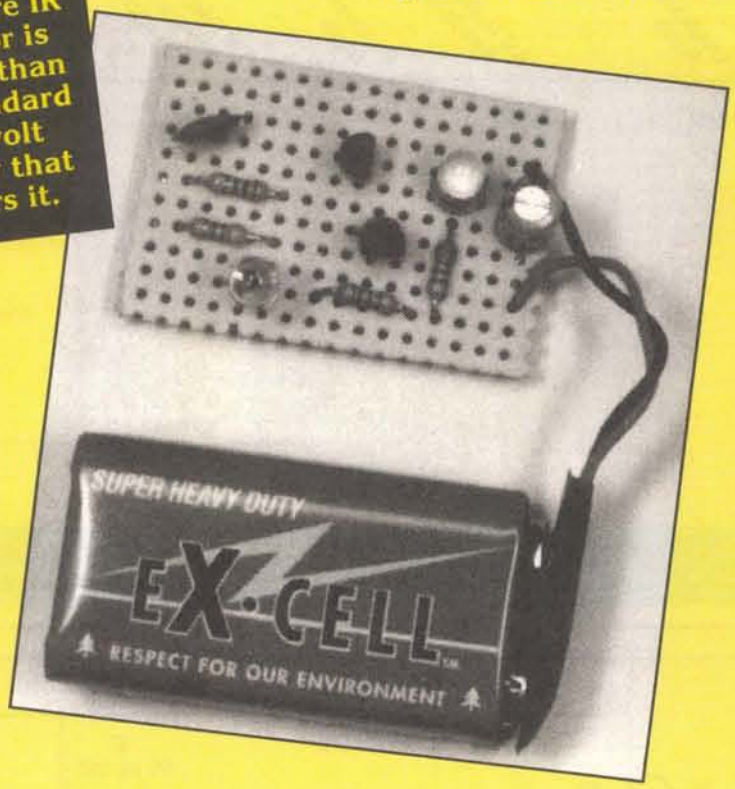
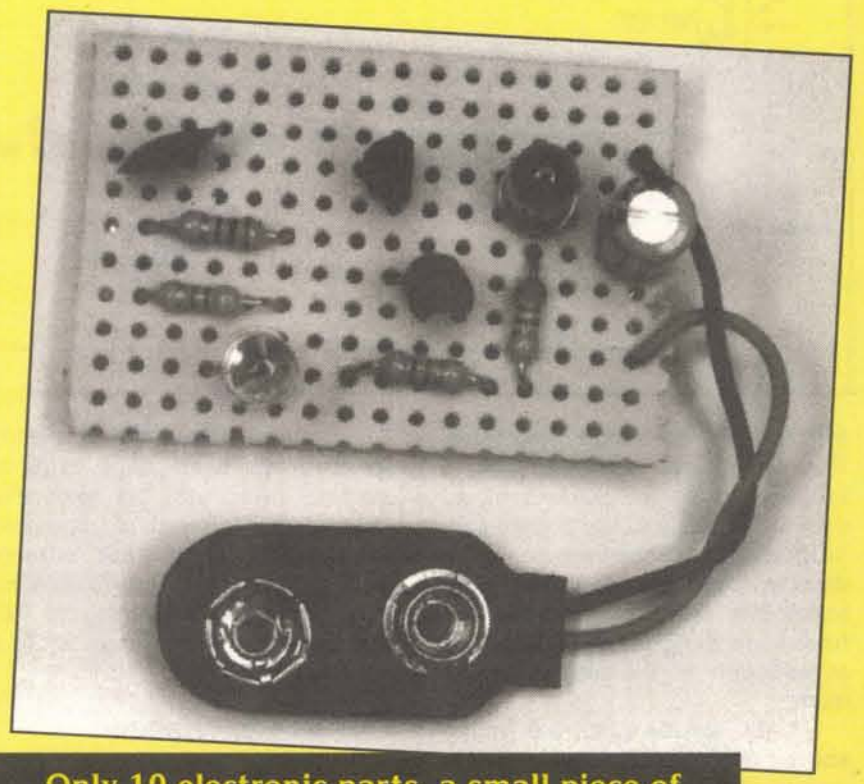
Build An Infrared Detector

by Fred Blechman

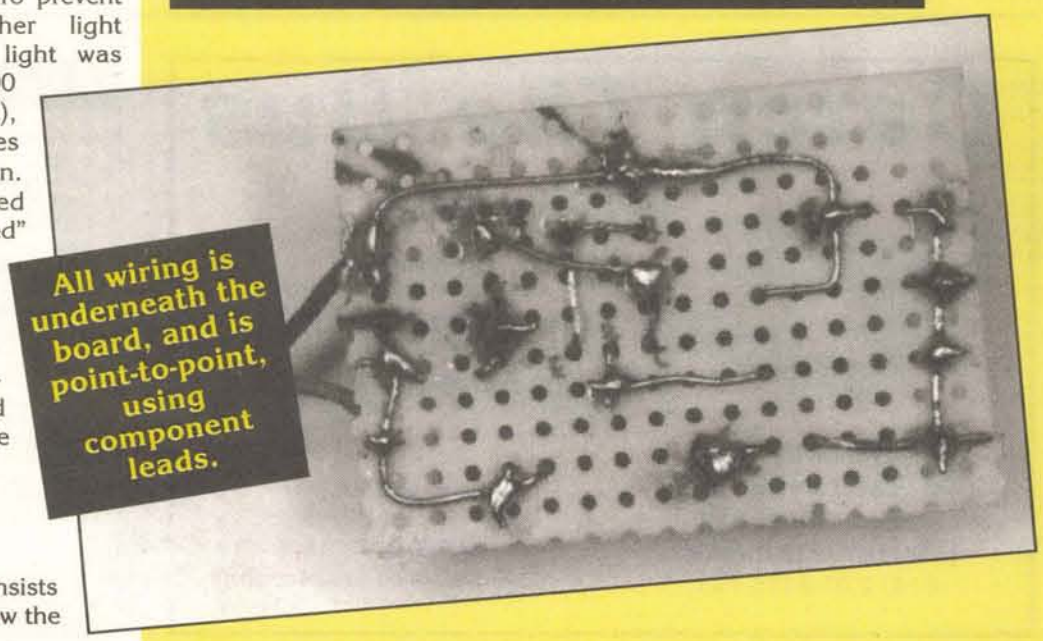
Build this simple circuit to test infrared remote controls. It uses only 10 common electronic parts you can get at any RadioShack store or order on-line. No printed circuit board is required and a common nine-volt battery will last "forever."



The entire IR Detector is smaller than the standard nine-volt battery that powers it.



Only 10 electronic parts, a small piece of perforated board, and a battery snap connector are used to build the IR Detector.



All wiring is underneath the board, and is point-to-point, using component leads.

They are everywhere!

You'll find them in living rooms, family rooms, breakfast rooms, dining rooms, and bedrooms. They may even be found in some bathrooms! What? Infrared (IR) remote controls.

IR remote controls are used to perform various functions for television sets, cable boxes, video cassette recorders, hi-fi audio sets, lights, ceiling fans, and a growing number of other electronic devices.

Increasingly, pressing various buttons on these remote controls are the ONLY way to perform some functions on these devices. Manufacturers, in order to save the cost and installation of switches and potentiometers, simply program a chip in the device to respond to infrared commands. For example, try to find a CONTRAST or BRIGHTNESS control on your modern TV set. Or clock controls on a VCR. These, and many other settings, have been relegated to the IR remote control designed for the specific device.

For the most common functions — ON/OFF, Channel, Volume, Play, Record, Fast Forward, Rewind, and others — a "universal" remote control can operate several different devices.

But what do you do when the control doesn't seem to work? Is there a battery problem? Is a button making contact when pressed? Is the control defective? Since you cannot see the infrared beam produced by these controls, how can you tell if it is working properly?

This dilemma is solved with the "IR Detector" which you can build from only 10 common parts.

Older Remote Control Methods

Probably the first use for remote control in the home came with changing television channels. At first there were mechanical methods, using a cable connected to the TV tuner. You physically pushed a button or turned a knob to change channels. Various means were devised to turn off the sound ("commercial killers"), some as simple as a flashlight beam shining on a photocell in the speaker circuit. However, daylight and sunlight could also trigger the sound off.

Pretty soon ultrasound — sound waves above human hearing — were used. This drove some animals wild, and was subject to interference from other sound sources.

But some years ago, infrared signals came into use. To prevent interference with other light sources, the infrared light was pulsed at around 38,000 cycles per second (KHz), with different pulse codes for each function. Therefore, infrared receivers could be "tuned" to about 38 KHz and decode the specific pulse train for each function. Infrared emitters and detectors coupled with programmed integrated circuits made all this practical.

Infrared Energy

Infrared energy consists of light rays that are below the

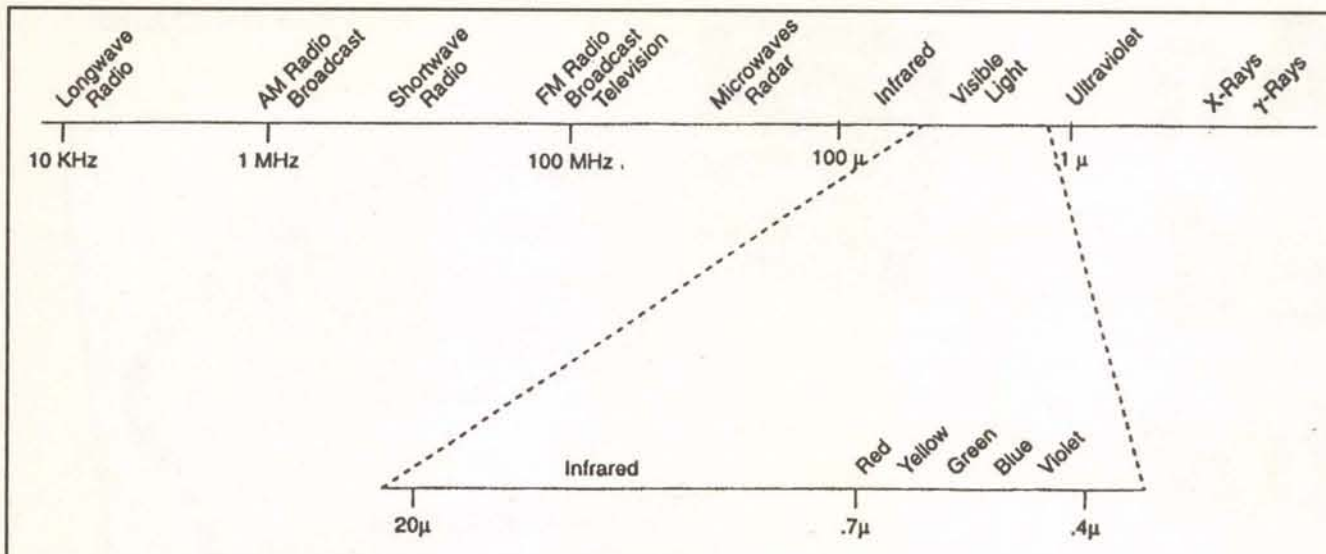


Figure 1 — Frequency spectrum from longwave radio to gamma rays, with expanded view of infrared to ultraviolet.

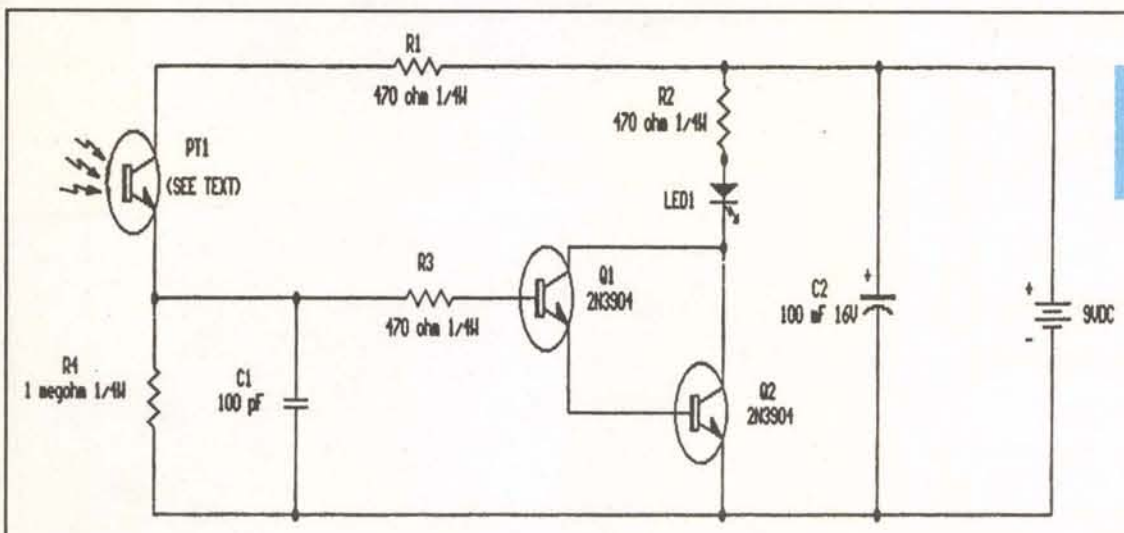


Figure 2 — IR Detector Schematic.

red end of the visible spectrum. The wavelength of these rays is longer than that of visible light, so they are invisible to the human eye. Infrared rays, however, can be detected by means of special photodetector semiconductors that have been designed to be sensitive to radiation in the infrared spectrum.

Light wavelengths are much shorter than typical broadcast and microwaves, and longer than x-rays. The higher the frequency, the shorter the wavelength.

Figure 1 shows the frequency spectrum from longwave radio to gamma rays, with an expanded view of the infrared to ultraviolet wavelengths. Note that infrared wavelengths are approximately from 0.7 micrometers to 20 micrometers. (A micrometer is a millionth of a meter.)

Circuit Description

The schematic of the IR Detector is shown in Figure 2. Powered by a simple, standard nine-volt battery, essentially no current flows through this circuit unless PT1, an infrared phototransistor, "sees" light. Since visible light also contains invisible infrared light, daylight and even artificial light will cause some current to flow in the circuit.

Basically, the circuit consists of the phototransistor, when responding to light, biasing a pair of transistors in a Darlington amplifier circuit so that current can flow through the light-emitting diode, making it glow.

PT1 has no base lead, since infrared light is intended to provide base bias. When there is no infrared light, little or no current flows from the collector to the emitter (the arrowhead symbol) of PT1. This means there is no bias voltage to the base of transistor Q1, so it does not conduct, also depriving transistor Q2 of bias, so Q2 does not conduct. Therefore, essentially no current flows through resistor R2 or light-emitting diode LED1. The circuit is dormant.

However, as soon as any light — especially infrared light — is allowed to fall on the transparent shell of PT1, the current from collector to emitter increases; the brighter the light, the greater the current. Resistor R1 limits the current through PT1, as well as providing a voltage-divider with resistor R4.

As current flows through PT1, a positive voltage is created at the intersection of resistors R3, R4, and capacitor C1. This voltage biases Q1 into conduction, which allows Q2 to conduct, thus providing a path for current to flow through current-limiting resistor R2 and LED1, which then glows.

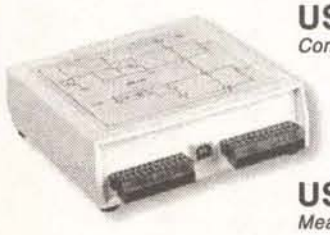
Since the infrared signals this detector is expected to receive are operating in a pulse mode with a basic signal frequency of about 38 KHz, capacitor C1 acts to filter out the signal and pulses, and electrolytic capacitor C2 stabilizes the power.

Construction

Before you can build the IR Detector you need to get the parts, some of which are so common you probably already have them. Nothing is critical in the layout or components of this circuit except for the infrared phototransistor, PT1.

Q1 and Q2 may be just about any NPN general-purpose silicon transistor, such as the 2N2222. The resistors, capacitors, and LED can be slightly different sizes or values. You might even find other phototransistors would work in this cir-

Catch The Bus



USB Relay Module
Control 8 to 16 "form C", 1 Amp relays
USB Opto Module
8 to 32 opto-isolated Inputs and Outputs
USB Digital Module
Industry standard 50 pin interface
USB Temperature Module
Measures temperature over multiple remote sensors

J-Works, Inc
12328 Gladstone St., Unit 4
Sylmar, CA 91342
(818) 361-0787 Voice
(818) 270-2413 Fax

Visit our Web site for free information on all our products
http://www.j-works.com
E-mail sales@j-works.com

Write in 179 on Reader Service Card.

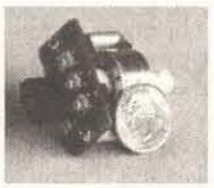
PROGRAMMABLE SOLENOID

- Low cost motion control
- Wide operating voltage (12 - 28)
- Onboard programming and parameter storage
- Self-contained electronics

Rotary (PPS-1)

$95.00 + $5 s/h

Linear (PPS-2)



$145.00 + $5 s/h

- Simple connection only 3 wires: Power, Ground, and CMD signal
- Long Life: Brushless ball bearing stepper
- Constant current Torque/Force

The Picard Programmable Solenoid (PPS) delivers the motion capability of a sophisticated stepper motor system with the simplicity of a solenoid. This eliminates the non-linear and erratic banging motion of a traditional solenoid. The electronics of the PPS allows the user to program and store the desired motion profile using the simple user interface. The innovative PPS gives programmability to the motion of a solenoid without the expense of a costly motion control system.

PICARD INDUSTRIES
Specializing in Miniature Smart Motors and Sensors
4960 Quaker Hill Road
Albion, New York 14411
Phone/Fax 716-589-0358
Email: jcamdep4@iinc.com
www.picard-industries.com

Write in 181 on Reader Service Card.

cuit, but I've found that RadioShack carries an acceptable unit, as well as all the other parts, as identified in the Parts List.

This simple circuit can be built on a perforated board, using point-to-point wiring. If a perforated board with holes spaced 0.1-inch apart is used, Figure 3 (enlarged view for readability) shows the perforated board holes and the parts layout I used for the IR Detector. Although the computer drawing program has distorted the shape of some of the components, the locations are accurate. Figure 3A shows the actual size.

Figure 4 (enlarged view for readability) shows the parts on the top of the board and the wiring paths UNDERNEATH the board. This wiring is accomplished by bending the component leads under the board and connecting them as shown. The only place it is necessary to jump one wire over another is, as shown, between the emitter of Q1 and the base of Q2.

Use care in soldering and orienting the parts properly. If you use the 2N3904 or 2N2222 transistors, when looking at the flat face of the transistor with the leads at the bottom, the leads are emitter, base, and collector (EBC) from left to right.

Note, however, that many types of general-purpose transistors will work in this circuit, and some have pinouts that are CBE. As a matter of fact, the unit shown in the photos — for you eagle-eyed readers — has such transistors, and they face in the OPPOSITE direction than the 2N3904 or 2N2222 would face. See Figure 3 for the correct orientation.

As for the phototransistor, the collector, which connects to R1, is the lead closest to the flat side of the clear plastic dome. The LED cathode, which connects to the collectors of both Q1 and Q2, is closest to the flat spot on the clear plastic dome. Most electrolytic capacitors identify the negative lead. The disc capacitor and resistors have no polarity.

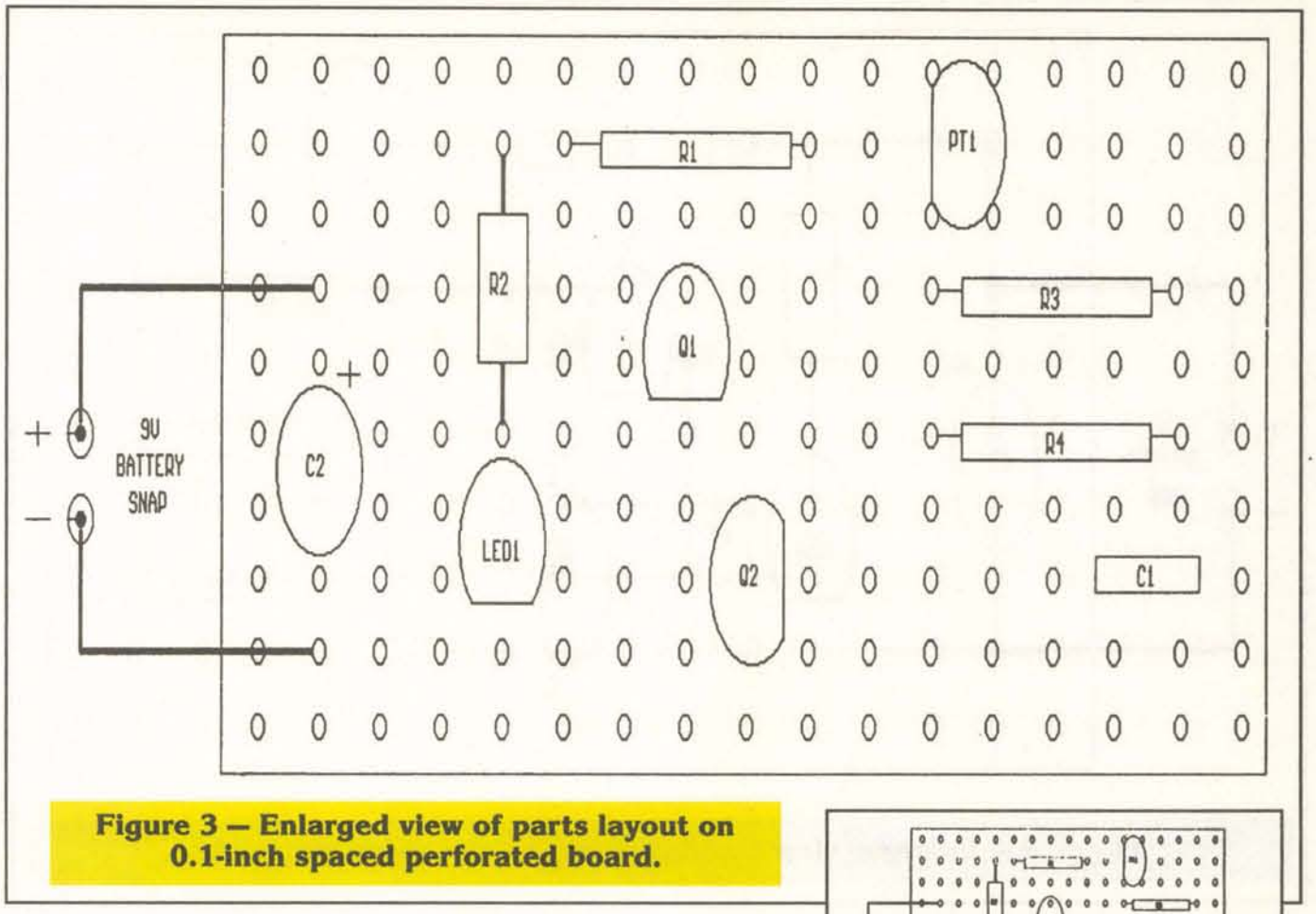


Figure 3 — Enlarged view of parts layout on 0.1-inch spaced perforated board.

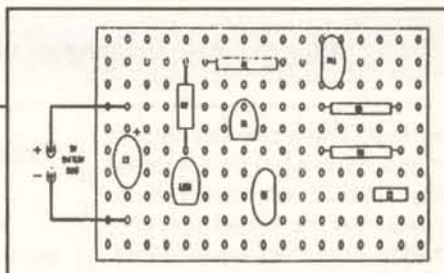


Figure 3A — Actual size parts layout.

Testing

Testing the unit is simple. All you really need is an infrared remote control and a nine-volt battery. It is not necessary to use an alkaline battery — zinc-carbon will do nicely. But only leave the battery connected when you will be using the IR Detector, since there is current flowing when any light (which usually contains some infrared) falls on the phototransistor.

It is necessary to test the unit in very dim light. This unit is VERY sensitive, and the LED will glow with any appreciable ambient light once the battery is connected. You can place a black tubular "hood" (such as can be made from a large soda straw wrapped with black tape to make it opaque) over the phototransistor to block light from the sides of the Detector. Or, you could mount the entire unit in a black box with just a small hole for access to the phototransistor.

With the battery connected, and the IR Detector in dim light, LED1 should not be glowing — or glowing dimly. Now, from six inches to a foot away, point the active end of the IR remote control directly at the photodetector, press ANY button, and LED1 should either flash once, or glow with a pulsing light. Some remote buttons only put out a single short burst, others continue to pulse.

Test all the buttons on the remote to see if the Detector picks up their signal. Some buttons, especially on older units, have developed high contact resistance internally, and some buttons may have to be pushed hard to make enough contact to emit a signal.

Also be aware that the selection of the device on universal

PCB LAYOUT
Software For Windows - FREE
1 Download our board layout software
2 Design your 2 sided plated-through PCB
3 Send us your layout over the Internet
4 In 2-3 business days, UPS delivers your boards, often under $100
www.expresspcb.com

World Passing You By?
Are you interested in Microprocessors & Embedded Control Systems? If not you should be! Look around, just about everything these days has an embedded microprocessor in it. TVs, cars, radios, traffic lights & even toys have embedded computers controlling their actions. The Primer Trainer is the tool that can not only teach you how these devices operate but give you the opportunity to program these types of systems yourself. Examples & exercises in the Self Instruction manual take you from writing simple programs to controlling motors. Start out in Machine language, then move on to Assembler, & then continue on with optional C, Basic, or Forth Compilers. So don't be left behind; this is information you need to know!
Examples Include:
- Measuring Temperature
- Using a Photocell to Detect Light Levels
- Making a Waveform Generator
- Constructing a Capacitance Meter
- Motor Speed Control Using Back EMF
- Interfacing and Controlling Stepper Motors
- Scanning Keypads and Writing to LCD/LED Displays
- Bus Interfacing an 8255 PPI
- Using the Primer as an EPROM Programmer
- DTMF Autodialer & Remote Controller (New!)

The PRIMER is only $119.95 in kit form. The PRIMER Assembled & Tested is $169.95. This trainer can be used stand alone via the keypad and display or connected to a PC with the optional upgrade ($49.95). The Upgrade includes: an RS232 serial port & cable, 32K of battery backed RAM, & Assembler/Terminal software. Please add $5.00 for shipping within the U.S. Picture shown with upgrade option and optional heavy-duty keypad ($29.95) installed. Satisfaction guaranteed.
EMAC, inc.
11 EMAC WAY, CARBONDALE, IL 62901
618-529-4525 Fax 457-0110 BBS 529-5708
World Wide Web: http://www.emacinc.com
1985 - 1998 OVER 12 YEARS OF SERVICE
Write In 180 on Reader Service Card.

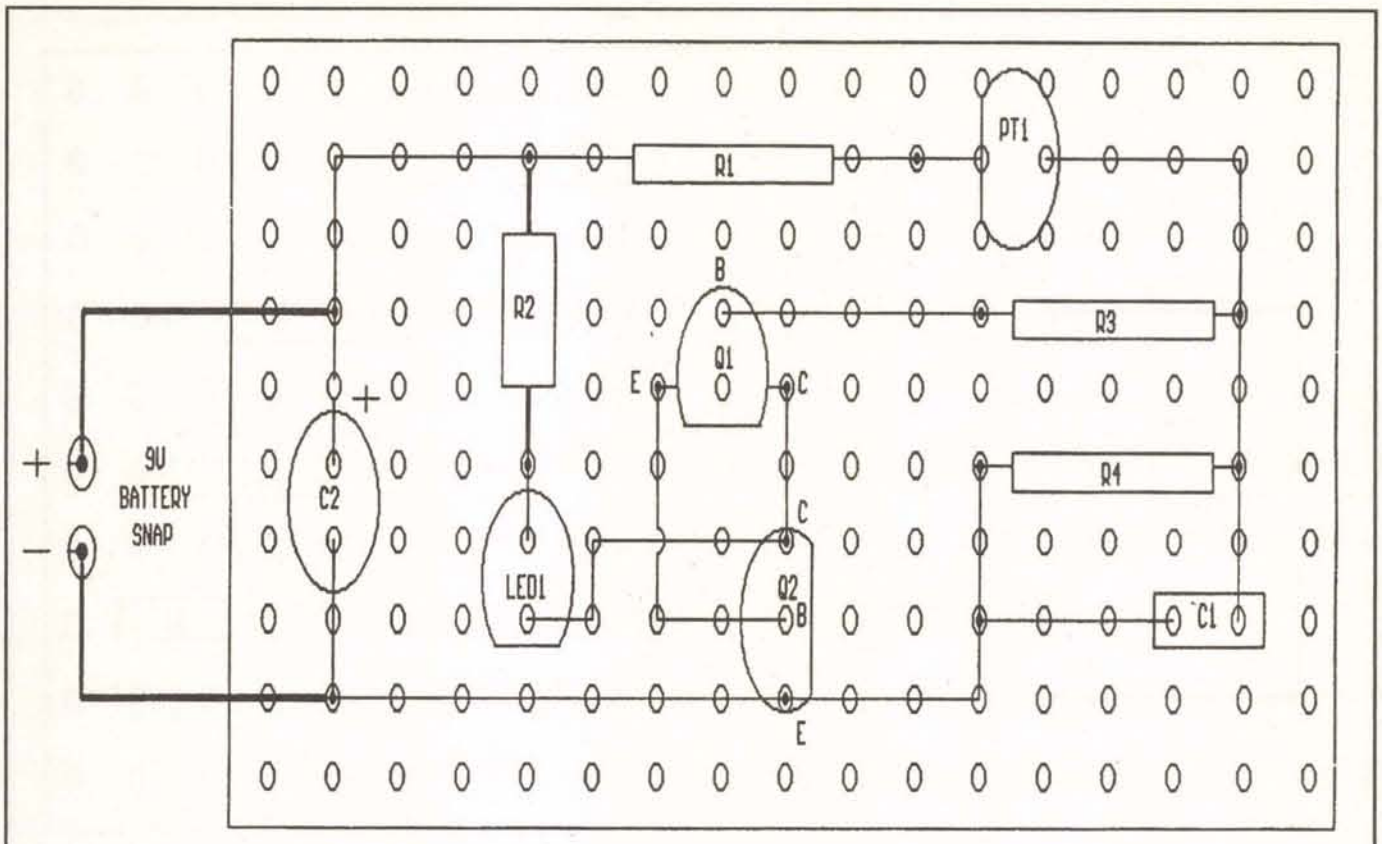


Figure 4 — Enlarged view showing wiring on the board underside.

Parts List

RadioShack (RS) or equivalent parts

R1, R2, R3 - 470-ohm 1/4-watt resistors (RS #271-1317)
R4 - 1-megohm 1/4 watt resistor (RS #271-1356)
C1 - 100pF 50V disc capacitor (RS #272-123)
C2 - 100mF 16V electrolytic capacitor (RS #RSU 11935210)
PT1 - Infrared NPN silicon phototransistor (RS #276-145) See text.
Q1, Q2 - 2N3904 NPN silicon transistor (RS #RSU 11328564) See text
LED1 - Red light-emitting diode (RS #276-041)
Perforated board - 0.1-inch spaced holes (RS #276-149)
Nine-volt battery - Alkaline (RS #23-875). Carbon-zinc okay.
Nine-volt battery snap connector - RS #270-325

remotes may affect the strength of the emitted infrared signal. I found selecting CABLE on one remote greatly reduced the signal strength, and I had to hold the remote closer to the Detector to light LED1.

Troubleshooting

What do you do if nothing happens during testing? Well, first you check the Detector battery and its polarity, then the orientation of all parts and the wiring between them.

Using a digital voltmeter with the battery connected to the snap, and the IR Detector in relative darkness, you should read about nine volts at the collector of PT1, at the positive side of C1, and at the intersection of R1 and R2. There should be little or no voltage at the base of Q1. The voltage at the cathode of LED1 should be about 7.5 volts.

When an infrared signal is aimed at the phototransistor, the voltage at the base of Q1 should jump to over one volt, and LED1 should light. If LED1 does not light, be sure it was not installed backwards.

Using an ohmmeter and Figure 4, check continuity between components to verify path and soldering.

Using

Use the IR Detector to verify the operation of any IR remote control that does not seem to be working. It may need batteries, or one or more of the keys may not be making contact when pressed.

When testing a UNIVERSAL remote — one that controls more than one type of device — be aware that it must be producing the proper codes to operate your specific equipment.

Even if the IR Detector indicates that the remote is producing infrared signals, the signals might not be the right pulse code for the particular device you are trying to control. In that case, you'll need to refer to the remote's instructions to set the proper codes for each device. **NV**

Metric
Equipment Sales, Inc.

800-432-3424
Fax: 510-264-0886
www.metricsales.com

RENT • BUY • SELL
Yes, we will buy your surplus equipment!

Scopes, Meters, Analyzers, Power Supplies, Signal Generators, Counters, Recorders and more

Hewlett-Packard, Tektronix, Fluke, Dranetz, TTC, Anritsu, Wavetek, Keithley, and more

Test & Measurement Instruments
Over 7000 Models • 6-Month Warranty
Save 30-90% • 5-Day Free Trial

FASTER THAN MOTOROLA

Two-way radio jamming equipment 800/900MHz. Stop illegal surveillance. **Pager jammers 900MHz.** Stop pagers from going off during school or church service. **Cellular phone jammers.** Stop cellulars from going off during school or church service. **PCS jamming, PCS phones. Lojack**/teletrack/boomerang. Stop illegal tracing/anti-surveillance. Cordless phone jammers 49MHz/900MHz • Radar jammers Xband • Nextel jammers • Car alarm jammer • CB radio jammer • Garage door jammer • RC radio jammers • AM/FM radio • HF/VHF/UHF radios • 1/8000MHz jamming equipment.

This equipment is designed for anti-surveillance customers: embassies, schools, churches, governments, law enforcement.

IF YOU DON'T SEE WHAT YOU WANT, WE WILL BUILD IT FOR YOU!!

We sell only to specific organizations or for export. Anyone implying illegal activity will be denied assistance and will be reported to law enforcement.

Jam RF • 954-561-8128 or www.jamrf.com

Write in 178 on Reader Service Card.